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When one engages in organizational diagnosis, it has been suggested that greater understanding of the organization can come through: (1) an identification of all the channels conveying material and information, and (2) a description of the means by which this communication influences the behavior of the organization. A networks/system approach is proposed as an analytical perspective for the empirical investigation of structure as it relates to decisionmaking and information processing in groups and hierarchical organizations. More specifically, the study incorporated the communication network paradigm as a vehicle for the study of group structure and its effects on decisionmaking and information flow. (Author)

THE IMPACT OF HIERARCHY AND GROUP STRUCTURE ON INFORMATION PROCESSING IN DECISION MAKING: APPLICATION OF A NETWORKS/SYSTEMS APPROACH

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ABSTRACT

When one engages in organizational diagnosis, it has been suggested that greater understanding of the organization can come through: 1) an identification of all the channels conveying material and information, and 2) a description of the means by which this communication influences the behavior of the organization. A networks/system approach is proposed as an analytical perspective for the empirical investigation of structure as it relates to decision making and information processing in groups and hierarchical organizations. More specifically, the study incorporated the communication network paradigm as a vehicle for the study of group structure and its effects on decision making and information flow.

INTRODUCTION

While a number of decisions which people make are quite personalistic, i.e., they concern only the particular individual involved, there are many occasions where persons make decisions as collective bodies as well, e.g., as committees, as groups, or as organizations. Very often these decisions deal with matters of concern to all members of the collective body but at times may also concern a larger society as well. A major problem in decision making is understanding the methods by which people combine information to make evaluative decisions.[1]

The decision arrived at by an organizational unit (i.e. individual, group, section, etc.) can be regarded as the output of the unit, whereas the information used for this decision and the rules or decision schemes (e.g., independent, quorum, plurality, etc.) for transforming it into the decision constitute its input. The decision making behavior of the organizational unit can thus be studied in terms of the relationships established between the inputs to and the outputs from the unit (Ramstrom, 1967).

In many organizational settings managers and other superordinates are concerned with the problems of (1) flow of materials, information, and understanding between the various units of the organization; (2) the manner in which organizational member characteristics affect organizational communication; and (3) the importance of the arrangements of the organizational units. For the present study we have utilized two terms or concepts which have been used extensively in describing organizational functioning, namely, "networks" and "systems", to develop a networks/systems approach to understanding how the above mentioned problems affect decision making activities in organizations.

By itself, a <u>networks</u> approach makes the assumption that an organization is composed of person-to-person networks, and the emphasis of this approach is on the attributes and characteristics of the organizational members. However, by itself, a <u>systems</u> approach views an organization as an integrated collection of mechanical schemes, and the emphasis of this approach is directed to the output facilitated by each arrangement. Thus, from a networks perspective an organization is seen in terms of its personal interaction patterns whereby the sociological, psychological,

and communication activities of the individual participants become the central focus of analysis. On the other hand, a systems perspective treats the organization as an integrated set of input-process-output arrangements in which each organizational unit makes its own demands on and contributions to the total organizational task (Vardeman and Halterman, 1968).

Our basic assumption in the present study is that an organization may be considered a system of overlapping and interdependent networks of groups.[2] Persons are structured into different systems of relationships, e.g., status structure, authority structure, work structure, friendship structure, etc., which may overlap but are not identical. The pattern of interpersonal relations is consequently called group structure. One strategy for the study of group structure under controlled conditions is to impose a formal structure upon a small group. Structure is thus treated as an independent variable and the consequences of a particular structure may be observed with regard to such dependent variables as group performance, interpersonal responses, and the personal reactions of its members. A second strategy is to regard group structure as an emergent phenomenon -- the interpersonal consequences of a set of persons interacting over a period of time, in which case group structure is regarded as a dependent variable. In either case, the concept is essentially the same and the notion of group structure is one of the important mediators between individual input and group output (Davis, 1969). The first of these strategies was used in the present study.

The idea of restricting the persons in a small group so that each member could potentially communicate with some members but not others (imposed structure) introduces the concept of communication network. That is, the communication network is the arrangement of information channels in a group or organization. Information is problem-oriented in both a broad and a specific sense. Any communication system where a problem is involved can be considered an information system. The communication network groups utilized in the present study formed the basis for the organizational components or decision units.[3]

The research reported here was concerned with small group decision making and had as one of its goals the determination of how structural

variables and interaction patterns of group members collectively affect group decision making and the degree of member satisfaction with individual and collective decisions. The diagram shown in Figure 1 illustrates the overall model used for the research study. As can be seen, there are actually three substudies associated with the model. Each substudy is dealt with in greater detail in Ford (1972).

Insert Figure 1 here

The study was concerned with the problem of combining the judgments of a number of group members into a single group-representative judgment, where each judge is required to assign to the item being evaluated one of a specified number of rating scale positions (i.e., a rating value). Some decision scheme is then used by the group to transform the responses of its members into the single desired judgment. Selections or choices from among the evaluated items were then made on the basis of the group judgments or evaluations. More specifically, general characteristics of this decision making process are as follows (Ramstrom, 1967).

1. The decision process is concerned with the selection of a certain subset of alternatives from among a number of available alternatives.
2. The decision implies a commitment by the decision maker to action. The decision thus constitutes an imperative for the decision making unit itself or for another unit in some way associated with it to behave in a specified way.
3. The decision is obtained by information processing. The decision base can be described in terms of the information available to the unit, and the transformation function indicates the nature of the operations undertaken with this information in order to reach the decision.

Thus, we are concerned here with groups formed for judgmental purposes, rather than for other purposes such as mere information exchange, idea generation, team play, or motivation. How structure affects the resulting

group response or decision is the central question under consideration. The specific independent and dependent variables related to the model in Figure 1 are presented in Table 1.

Insert Table 1 here

The structural variables were incorporated in a laboratory experiment through the use of the communication network paradigm (Bavelas, 1950; Leavitt, 1951). This afforded the means by which we could study the effects of organizational complexity and subgroup structure upon (1) the decision making behavior of subgroup members, (2) the behavior of the subgroup's representative or leader at a higher level organizational setting, (3) the flow of information within the subgroups and organization as a whole, (4) subgroup and organizational performance, and (5) member attitudes and feelings based on their experiences in the group. Only items (1), (3), and (4) are dealt with in this presentation.

The rationale for using the communication network model as a framework for the present research is twofold. First, understanding of the working relationships among members of task force groups, whose parent organizational subunits which they represent vary along a structural dimension, (e.g., formality of rules,requirement of having to go through channels, etc.) can be gained through using such a framework. Secondly, of the means available for manipulating structure as an experimental variable and having the effect "take," the communication network model is one of the most successful (Davis, 1969).

Organizational complexity in this study was defined in terms of the kind of subgroups which comprised each of the laboratory "organizations" studied. With very few exceptions, previous studies involving communication networks have limited their investigations to small groups working in isolation. Actually, small groups typically perform as subgroups which are parts of larger networks or organizations. Here we used the communication network paradigm as a basis for studying complex organizational structure and its effects on decision making activities. The laboratory organizations were formed by combining several independent

small network groups into a "group form" of organization (Likert, 1961, 1967). Likert proposed an idea of superimposing upon the traditional line - staff organization a functionally overlapping grouping of individuals to better interlock the various portions of the intact line and staff, that is, a "linking pin" concept. The present research is an example of carrying Likert's proposal to its logical end by formally organizing our laboratory organizations such that the only structure is that of overlapping groups or committees.

Structure was manipulated through variations in organizational complexity; that is, subgroup structure is nested within organizational structure, and as subgroup structure changes so does the organizational structure and complexity (see Figure 3). The major dependent variables as shown in Table 1 were (1) member ratings of multi-attribute alternatives, (2) group ratings of the same alternatives, (3) the expressed attitudes of members toward their group experiences, and (4) organization and subgroup performance in terms of time taken to complete the required task. The results regarding items (3) and (4) are not reported here, but are reported in detail in Ford (1972). Item (1) was used to derive and test several mathematical models of information processing strategies of the organization members using methods and procedures similar to those described in Huber, Daneshgar, and Ford (1971). The rationale was that a starting point to understanding how groups of individuals make decisions is to try to understand the decision making behavior of the individual.

In recent years there have been a number of studies in the area of information utilization in judgment and decision making. Many of these studies have been concerned with the questions, "What is the decision maker doing with the information available to him?" and "What should he be doing with it?" (Slovic and Lichtenstein, 1971). These studies have tended to focus on the processes and strategies that people employ in order to integrate discrete items of information into a decision. Several mathematical models have been proposed in the recent literature as representations of the combining process and the present study investigated five of these models in order to determine the best fit equation form which more accurately described the decision makers' subjective evaluation models.

METHOD

Concept of Organizational Complexity. Two types of decision network subgroups were used in the study. One type was such that the group members could communicate only with their group leader or representative and not directly with each other. This type was designated as a "wheel" (W) network. The other type of network was such that all members could communicate directly with each other. This type was designated as a completely-connected or "all-channel" (AC) network.[4] Whereas a majority of previous network studies have been concerned with five-man networks, the subgroups in this study were three-man networks. Questions concerning the qualitative differences between networks of different size and the appropriateness of using the above names for different sized networks have been raised in the literature (e.g., see Collins and Raven, 1969). However, I believe these differences are unimportant in the context of the present study and that, in general, it is the overall characteristics of the networks, regardless of size, that matter.

The design for the laboratory organizational structures which were used is shown in Figure 2. The design depicts an organization with two levels of "hierarchy." The group members completed their decision making tasks at level 1 (subgroups) and the outputs or collective decisions of the individual groups served as inputs to the decision making process and task at level 2 (supergroup) of the organization. At level 2 the leaders or representatives of each subgroup met as a task force and acted upon the recommendations from the subgroups. The final organizational decision was the output of the supergroup. As can be seen in Figure 2, the group leaders or representatives served as the linking mechanisms for the organization.

Insert Figure 2 here

The various possible combinations of wheel and all-channel networks at both levels of the organization give rise to eight different structures of organizational complexity as shown in Figure 3. For convenience, these eight structures may be thought of as being arranged along a continuum

from centralized (01) to decentralized (08) organizations. The subgroup structure superimposed over the other three subgroups represents the supergroup task force at level 2 of the organization. Of the eight different organizational configurations shown in Figure 3, only two, 02 and 08, were examined in this study for several reasons. First, it was felt that the maximum variance in the dependent variables would occur with the "extreme" conditions. Second, with regard to behavior of the members of the supergroup at level 2, comparisons between organizations can be made in terms of type of background of the supergroup members (type of level 1 network) without background being confounded with different structures at level 1. That is, homogeneity of supergroup members' task force network structure is maintained with organizational types 02 and 08. While this is also true for organizational types 01 and 07, the former two were chosen because of a particular interest on the experimenter's part to investigate type 08.

Insert Figure 3 here

In addition, it has been shown in previous studies dealing with network change that the kind of relative contrast between the structure that followed and the one that anteceded it played significant parts in every major aspect of the group's functioning (Cohen, 1964; Cohen, Bennis, and Wolkon, 1962). In essence, "...the history of a group interacts with its present structure to generate behaviors and expressions of sentiments different from either of these factors alone" (Cohen, 1971). Therefore, our rationale for the second point above is partially supported by research findings.

Subjects. The subjects were 72 volunteer undergraduate and graduate students in industrial engineering and business at a large midwestern university. They were randomly assigned to two subsamples, 36 subjects in each subsample. Subsamples 1 and 2 corresponded to subjects who worked in wheel and all-channel decision networks, respectively, at level 1 of

the laboratory organizations. The subjects were run nine at a time, with three subjects being randomly assigned to each of three subgroups. A group leader or representative for each group had been previously designated by the experimenter (randomly determined). This person's job was to serve as representative of his group for the supergroup or level 2 task.

Experimental Apparatus. Unlike previous studies involving communication networks in which only written messages between group members were used, voice communication between subjects was used for this study by means of a telephone system hookup. Indeed, the network idea in principle should be applicable to vocal exchange. It is therefore surprising that so little attention has been directed to the experimental study of networks in which members communicated by intercom. Only two such studies appear to be available, Heise and Miller (1951) and Davis and Hornseth (1967). The scarcity could possibly be due to the potential contaminating impact of verbal expressions, inflections in voice, tone loudness, etc.

A schematic wiring diagram of the telephone system which was used is shown in Figure 4. As can be seen, a system of nine telephones, consisting of three subgroupings of three phones each, allowed all three of the level 1 subgroups to be conducted simultaneously. In addition, the system was such that the experimenter could monitor each subgroup's discussions and he had direct communication with each subgroup's leader. Structure with in each subgroup was determined by the open communication channels between subgroup members which could be changed at any time by the experimenter in order to produce wheel or completely connected network groups. Thus, while verbal communication was used to give an added dimension of reality not found in previous network experiments, the groups were interacting non-face-to-face groups. This type of structure does not fit within any of three borad classification of various types of groups given by Lorge, Fox, Davitz, and Brenner (1958).

Insert Figure 4 here

Experimental Procedure. The subgroups of the laboratory organizations were required to interact, at least in part, through their respective representatives in the service of integrating the decisions of the functional subgroups to produce a final decision for the entire organization.

After subjects had been randomly assigned to experimental conditions, written and verbal instructions about the subgroup and total organizational tasks were given along with an explanation of the post discussion procedures. Those persons who were to occupy the leader or group representative position within subgroups were identified and their roles in relation to the subgroup and organizational tasks explained.

Experimental Task. The task required of each subgroup was to evaluate fifteen hypothetical teaching professors described in terms of five qualitative factors. The descriptions were not those of any actual professors and the subjects knew this. Members of the subgroups had previously rated the same hypothetical professors privately as individuals. The purpose of the subgroup was (1) to discuss their individual evaluations, (2) to develop, as a group, overall evaluations of the 15 professors, and (3) to identify, so as to recommend for award, the five most outstanding professors in the set of descriptions under consideration. Each level 1 subgroup within a laboratory organization had a different set of 15 descriptions to consider. Description sets were randomly distributed across groups of different structures. An example description is given below.

> He has an excellent mastery of the subject and possesses a wide fund of knowledge in other fields. Usually he is adequately prepared, but frequently seems disorganized. He asks the best work from the students but is sometimes satisfied with average workmanship. He expresses himself clearly and enthusiastically; his diction is very good. He generally will listen to all viewpoints, but at times appears to be disturbed and impatient when students oppose his views.

Prior to the group discussions the procedure described in detail in Ford (1972) was followed. Very briefly, each subject was asked to evaluate each of the described professors on a 0-100 scale which recorded his "level

of "satisfaction" with the professor described. This rating is noted as U. Secondly, each subject was asked to indicate, on a 0-100 scale, the rating, x_{nl}, that he would give to a professor who was described solely in terms of the l^{th} level of the n^{th} factor. The order of appearance of the factors within descriptions and of the levels within factors was randomly determined. An example of a completed recording instrument is shown in Figure 5. The "graphical" scaling procedures used here have been shown by Hoepfl and Huber (1970) to produce reliable ratings of criteria, which is what these factors are.

Insert Figure 5 here

Having completed these evaluations (prior ratings) the subjects then met and discussed their evaluations in the different three-man subgroups to which they had been assigned. These subgroups corresponded to those associated with either 02 or 08 (see Figure 3). No decision rule for final evaluations of the professors by the subgroups was specified. Rather, the members decided among themselves how their final decisions were to be determined and the selection of the "chosen" subset of five most outstanding professors.

Following the group discussions at level 1 the group members then completed a post-discussion questionnaire which (1) solicited measures of their attitudes and feelings with respect to various aspects of their group experiences, and (2) also asked the subjects privately to reevaluate the professors they had previously evaluated (post ratings) and also to evaluate a different set of 15 professors (revised ratings). The purpose of these post-discussion ratings was to determine what modifications, if any, occurred in the subjects' decision models as a result of their group interaction.

The primary analysis using the rating data consisted of comparing predicted evaluations, obtained using the five mathematical models shown in Table 2, with the actual ratings given by the subjects. The raw data was developed into a useful form by using multiple regression procedures to estimate the parameters of the five models. The ratings represented by the U's in the models were used as dependent variables and the x_{nl}'s

were used as independent variables to estimate the U_o and u_{n1} parameters, and R, the multiple correlation coefficient, was computed for each subject for each of the five models for each set of ratings.

Insert Table 2 here

After the post-discussion questionnaires were completed, the leaders or representatives of the respective groups met to discuss and evaluate the various professors recommended by each group and to decide which were the five most outstanding professors among all those recommended. Since each group had originally evaluated a different set of professors, data concerning the professors recommended by the other groups was provided to each member of the task force group. Each group representative had been encouraged to try to persuade the task force group to accept his respective subgroup's recommended professors as the most outstanding. He was also told that his subgroup members would be evaluating his performance on the basis of how many of their recommended professors appeared in the final organizational recommendations made by the task force supergroup. During the supergroup meeting the other members of the subgroups met with the experimenter to discuss, in a general fashion, their overall reactions to the experiment. Afterwards, the group leaders then completed a second post-discussion attitude questionnaire regarding their supergroup experiences. Finally, when all questionnaires were completed by all members, the experimenter debriefed the subjects with respect to the purposes of the experiment and answered any questions which were not possible to be answered in the earlier session.

RESULTS

Research Hypotheses. Since there have been relatively few previous studies involving networks as parts of larger, more complex organizations (Cohen, et al., 1969; Cohen, 1971 are exceptions), hypotheses were based, in part, on extensions of the results obtained from prior studies of isolated communication network groups in centralized and decentralized patterns, and from studies of decision making groups in laboratory settings. This allows

a direct comparison and test of generalizations of certain findings from small communication networks in isolation to larger and more complex organizational forms. There were two sets of hypotheses associated with the study. These are presented below along with the results of their analysis.

Hypotheses Concerning Information Processing Strategies of Group Members. Multi-attribute utility[5] models are designed to obtain the utility of items or alternatives that have more than one value enhancing property. Such models, when they can be obtained, can be useful in many situations, for example, in aiding decision makers to make explicit some of their objectives. In another vein, persons whose interests focus on human behavior have a means in utility models of predicting the evaluations (and/or choices) made by decision makers.

The general finding from a number of studies over the years which involved empirical comparisons among competing models have been that a linear compensatory model provides as good a representation of the information processing strategies of decision makers as have other models examined to date (Goldberg, 1968, 1971). In those studies involving the use of non-linear models for combining information, the results have been somewhat disappointing (Wiggins and Hoffman, 1968), with the exception of several studies by Einhorn (1970, 1971, 1972). The present study incorporated linear and nonlinear models as representations of the strategies used by decision makers. The analysis, however, focused on the decision strategies of group members following group discussion.

Two hypotheses were examined:

1. H_o: Following group discussion subjects will modify their decision/information processing strategies from the ones used prior to discussion. Modifications will occur for a larger proportion of subjects in unstructured (all-channel) decision networks than for subjects in structured (wheel) decision networks.
2. H_o: In addition to modifying their decision strategies, group members will experience some degradation in reliability in the use of their

> decision strategies following group discussion. The mean decrease in reliability will be larger for members in all-channel decision networks than for members in wheel networks.

Table 3 summarizes the multiple correlations associated with each of the five models of information processing strategies. In comparing the mean R values across models, none of the pair-wise possible comparisons were significant using the Newman-Keuls test (Kirk, 1968) for either set of ratings given by the subjects.

Insert Table 3 here

In order to ascertain the inter-judge differneces, the data for each set of ratings are summarized in Tables 4 and 5 for subject samples 1 and 2, respectively. These tables indicate the model form that provided the best representation of each subject's decision strategy, based on the magnitude of the associated R values. Differences between the sets of ratings can be determined by reading across the rows of these tables. By reading down the columns the reader can determine the inter-judge differences. As indicated by the tables, there were noticeable inter-judge as well as inter-rating-set differences.

Insert Table 4 here

Insert Table 5 here

With respect to the first hypothesis, it can be seen from Tables 4 and 5 that a number of subjects did appear to modify their decision strategies following group discussion, as shown by their best fitting model. For the members in wheel decision networks, 14 changes occured

with the post ratings and 23 changes occured with the revised ratings. These proportions are .38 and .64 respectively. The proportion of changes are even higher for members in the all-channel networks, where 19 and 32 changes occurred for the post and revised ratings, respectively. These proportions are .53 and .89. The difference in proportions for the two types of decision networks was not significant for the post ratings but was significant at the .05 level for the revised ratings using the binomial approximation to the normal distribution. Therefore, hypothesis 1 was partially supported.

With respect to the second hypothesis, it can be seen from Table 3 that a slight decrease did occur in the mean R values of the subjects' post and revised ratings, indicating a slight decrement in the reliability of the subjects' use of their decision models. However, these decreases were not statistically significant. In general, the size of the decrease in R values was about the same for both subsamples of subjects.

Clearly, individual differences can be expected to play a large part in any decision problem. When each judge is considered individually, considerable variability of the decision process and lack of generality in terms of the kinds of methods judges use to arrive at their decisions becomes very apparent. However, if one averages across judges one may lose these important individual data. This problem as well as other factors which affect decision making are dealt with in the discussion section.

Hypotheses Concerning Influence of the Group and the Effects of Structure. Goldberg (1955) brought to the network studies a new task, the unstructured group decision task, and a new dependent variable, influence (or more precisely, influenceability). He hypothesized that in group decisions, central positions in a network would be influenced less than peripheral positions. He placed subjects in 5-man wheel, Y, and chain networks and showed a card bearing a number of dots. The subjects then communicated with each other and settled on an estimate of the number of dots. Influence, measured by the amount that a subject changed his initial estimate during the experimental session, was found to be negatively related to the centrality of the position only for the Y network. The study by Shaw, Rothchild, and Strickland (1957) employed the use of unstructured decision tasks. Each

member of the group started with all the information required for a decision. The group members had to interact only to reach an agreement on the solution. The wheel required the longest time and the all channel required the shortest. Other results of this study also indicated that, in general, the amount of change that a subject was willing to make was a function of the amount of support and opposition he faced rather than any position characteristics.

Arguments concerning the convergence of group members' opinion have been advanced in experiments on risk taking in which the phenomena of "risky shift," "cautious shift," and/or "group shift" have been observed (Davis, 1969; Pruitt, 1971a,b). A number of alternative explanations for this phenomenon have been proposed in the literature. The question of group shift per se was not an empirical question for this study. However, it is possible that any observed change in prior opinion of a subject can be explained by one of the proposed alternative explanations (see Pruitt, 1971a,b, for further references on group shift experiments).

More likely than not, potential for greater influence by the group exists with the all channel network than with the wheel network because of the potential for greater information exchange and more information available to bring to bear on the problem. On the other hand, the possibility also exists for a coalition of two against a minority of one person in the present study. However, in the absence of a chance for social comparison of opinion by peripheral members of the wheel network, a very strong and dominant central member may be able to exert quite a bit of influence on the other two members.

The above framework suggests the hypotheses indicated in the discussion below and in Table 6.

Insert Table 6 here

Due to the greater opportunity for discussion by all members of the completely-connected subgroups, it was hypothesized that post-discussion agreement would be higher for these group members than for members of wheel subgroups. Although hypothesis 3 was not supported, the difference was in the predicted direction.

A comparison of the post utility models of the wheel and all channel group members failed to show any significant differences between them. The same was true when the revised models of the wheel and all channel group members were compared. Thus, hypotheses 4 and 5 were not supported by the results, i.e., the null hypotheses could not be rejected.

Group discussion served to increase the consensus of the group members regarding the alternatives under consideration (Ford, 1972). The group convergence toward consensus, it was thought, would be reflected in the post discussion ratings being closer to the group ratings than would be the case for the pre-discussion ratings. Hypothesis 6 was partially supported, with the group and post discussion ratings being significantly more alike than the group and pre-discussion ratings for the all channel groups. Although the hypothesized difference was not significant for wheel subgroups, the difference was in the predicted direction.

DISCUSSION

A portion of this study has examined several mathematical models as possible representations of the strategies that people employ in order to integrate discrete items of information into a decision. The initial analysis was concerned with the processing of information that precedes and determines decision making. This is what has been termed the correlational paradigm within the broad area known as regression approaches to the study of information processing in judgment. One area of focus within this approach, and the one most applicable to the present study, is the stream of research which focuses on the judge: "...its goal is to describe the judge's idiosyncratic method of combining and weighing information by developing mathematical equations representative of his combinatorial processes" (Slovic and Lichtenstein, 1971, p. 655). The most important element investigated, then, is the rule by which the subject combines or integrates the input information.

The results in Tables 4 and 5 indicated considerable use of linear and non-linear decision strategies by the same subject on different occasions. Contrary to many other studies, a linear model was only marginally better than other model forms in representing the subjects' decision strategies.

Effects of Structure on Consensus Convergence. The results for the effects of group structure on the decision making process within the groups and on the members' decision models is mixed and not as clear as one would wish. An analysis conducted in conjunction with hypotheses 4 and 5 but not reported earlier involved a comparison of differences in mean values of the multiple correlation coefficients for various sets of ratings. The results indicated a general pattern in which there was a slight decrease in mean R values for post and revised ratings from the values observed for the prior ratings. None of the differences or decreases in value were statistically significant for either of the models. It thus seems that while group discussion increased consensus among the subjects, it also decreased the accuracy of their judgments. This could be due to any number of causes. One possible explanation could be the extent to which opinion change was necessary on the part of the subjects. The apparent convergence of opinion toward consensus on evaluations of the alternatives necessitated opinion change that was, in fact, not in keeping with the manner in which the subjects actually weighted the attributes, thereby decreasing the reliability of their models.

If we consider the within sample differences in mean R values for prior ratings versus revised ratings, overall the decrease in magnitude of the R values is larger for subjects in the all channel groups (sample 2). If we consider the within sample difference in mean R values for post versus revised ratings, then overall the decrease in magnitude of the R values is larger for subjects in the wheel groups (sample 1). However, in both instances, the one exception is the disjunctive model; in addition, these conclusions are largely tentative given the very small magnitude of the differences (see Table 3).

If we can interpret the difference between the group ratings of the designated chosen alternatives and the members' post discussion rating of these same alternatives as the experienced disagreement of the individual as suggested by Delbecq, et al. (1968), then an examination of the mean differences for wheel and all-channel groups indicated that the mean difference was less for all-channel groups than for wheel groups, but the difference for both types of groups was not significant. That is, members of the wheel groups experienced greater disagreement with the

group evaluations of the alternatives even though their reassessments were closer to the group ratings than were their prior ratings. Miller (1971, p.347) discusses an experiment on jury panels with a similar finding. It seems as though the group decisions in that study were arrived at by explicitly making rough averages of individual estimates of the members. Individual members did not always agree with the group decision but supported it because the jury had to have a unanimous decision if it was to be implemented and if a hung jury was to be avoided. Although a unanimous decision was not explicitly required of the groups in the present study, it does seem that a similar process may have taken place in the wheel subgroups in order for them to make a decision, since communication channels between members other than the leader were unavailable.

Another phenomenon which we suspect was present, but for which we have no supportive data to verify our suspicions, was the use of two or more models simultaneously by the subjects, or the switching back and forth between different "logics." Churchman and Eisenberg (1964) call the process by which an information processor (i.e., decision maker) transform inputs into decisions his "logic." Discussion and deliberation do not affect some judges, i.e., their personal logic still predominates in making evaluations and choices, whereas with other judges the deliberation process is an aid to their decision making process in that they are better as judges for it than they were alone. The group discussions apparently evoked several alternative logics which were used by the subjects in making their post discussion evaluations and the subjects were unable to use one consistently as a result. Coupled with the fact that personal logics are usually deficient in one or more areas, e.g., preweighting of alternatives, ignoring information, or ignoring alternatives, the use of several logics and the switching back and forth between them may have caused the decrease in reliability of the post and revised utility models of the subjects. Note that in quite a few cases, the best fitting model of the subjects' decision strategies following discussion is different from that before discussion for both sets of ratings, indeed indicating some degree of logic switching.

It is, of course, possible that any number of different explanations

could be given for the results obtained here. Presumably, we have discussed the more appropriate ones, since our results corroborate, to some extent, the findings of earlier studies. The findings here, however, are not as conclusive as one would wish. The phenomenon observed in testing hypothesis 6, i.e., whereby members tend to make their reassessments of the alternatives closer to the group assessments than to their original assessments, is indicative of a general phenomenon of "choice shift." (Pruitt, 1971a,b). This seems more appropriate since the alternatives involved in the present study did not have a risk dimension; therefore shifts in opinions of group members would not necessarily indicate a risky shift or a cautious shift. Moreover, in attempting to explain the impact group discussion and interaction have on subjects' decision models, any number of explanations could be put forth.

Several hypotheses that have been suggested by researches reviewed in the Pruitt articles are that (1) group discussion causes a change in the utilities which individuals assign to the outcomes that are associated with the options available, (2) group discussion leads to convergence on the utilities associated with the various possible outcomes, and (3) arguments heard in a group discussion produce utility changes which, in turn, produce shift. We think that possibly all three hypotheses could apply to the present study. Perhaps our analysis associated with testing hypotheses 4 and 5 was one step removed from what it should have been. Our assumption that changes in utilities would be reflected in changes in the associated multiple correlation coefficients may not have been completely appropriate and perhaps what was needed was a closer examination of the actual utilities themselves. It is difficult at this point to determine post hoc how much each of the hypotheses just cited contributed to any changes in subjects' utilities and/or choice shifts. The third hypothesis is a contender for explaining only that part of the shift which is added by group discussion over and above that produced by information exchange. The present study was not designed to answer such a question nor was it concerned explicitly with the question of choice shifts. These are questions of investigation for future research studies.

A number of variables were not controlled for (e.g., personality, intensity of feeling in communication, skills in social interaction,

homogeneity of prior consensus) and it is possible that these methodological shortcomings may account for some of the observed results in spite of the fact that we attempted to minimize the effects from extraneous and exogenous variables by randomly assigning subjects to experimental conditions.

While the precise effects of structure on information processing by the group members are not clear, they are, nonetheless, evident. The present study was typical of many ad hoc groups in which the experimental laboratory groups did not have time to become integrated and develop significant and influential interpersonal relationships. Consequently, the possibility exists that with laboratory groups, it is hard to demonstrate the complex interactions which occur in natural groups, and the laboratory groups may reflect more the processes and norms of society more so than those of the groups themselves.

Before we can bridge the gap between laboratory data and real world organizational applications, we must identify those "boundary variables" which delimit extrapolation of the findings from laboratory groups beyond the current setting (Fromkin and Streufert, 1973). Work is presently underway toward this end with the present study.

Finally, we recognize the need for developing more complex models to deal with cognitive functioning and information processing, as well as the expression of these complex models mathematically. Ideally, models of group decision making should include measures of personality variables, group interaction patterns, and individual utility functions which can be used to ultimately predict group decisions.

FOOTNOTES

1. Decision making as defined by Huber (1970) involves the combined process of evaluation (the assignment of numbers to several items are alternatives which represent their value), and the determination of a value which separates the alternatives into classes which will be acted upon differently, e.g., acceptable and unacceptable. Evaluations presented on an ordinal scale are called rankings; if presented on an interval scale, they are called ratings.

2. For our purposes we will not distinguish between the terms network and group. Group as used here involves some form of interaction and so is used synonymously with the concept of network.

3. Thus, communication network and decision network are considered synonymous here though the two may not necessarily coincide in actuality.

4. These names are the same as those that have been used in previous studies of communication networks where the wheel is the most centralized network in which one central member has communication channels to all other members of the network but they, in turn, can only communicate with the central member. The completely connected, or all channel, network is the most decentralized network in which every member can communicate with every other member of the network.

5. We use the term utility here in its "broad" sense or meaning, as have others (cf. Fishburn, 1964, 1968), and take it to be synonymous with other concepts such as preference, value, desirability, worth, and goodness.

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TABLE 1

Experimental Variables

Independent Variables	Dependent Variables
A. Variables Manipulated	A. Derived Outputs
1. Organizational Complexity (see Figure 3)	1. Utility Functions
2. Subgroup Structure	a. Individual post[@] utility functions
a. Wheel network	b. Group utility functions
b. All-Channel network	
B. Variables Brought to Experiment by Environment	B. Observed Outputs
1. Utility Functions	1. Ratings of Alternatives
a. Individual prior[*] utility functions	a. Individual post ratings
	b. Group ratings
2. Experimental Task	2. Member Satisfactions
a. Individual prior ratings of alternatives	a. With subgroup ratings
b. Group task	b. With status and job in the group
	c. With supergroup[+] ratings
	3. Subgroup Task Completion Times
	a. Level 1 groups
	b. Level 2 groups

[*] Prior refers to before-group interaction.

[@] Post refers to after-group interaction.

[+] Supergroup refers to the task force group at level 2 of the organization.

TABLE 2

Summary of the Five Mathematical Models

Name	Conceptual Formula	Computing Formula
LINEAR	$U = U_0 + \sum_{n=1}^{N} u_n x_{n1}$	$U = U_0 + \sum_{n=1}^{N} u_n x_{n1}$
CONJUNCTIVE (CONJ)	$U = \prod_{n=1}^{N} U_0 x_{n1}^{u_n}$	$\text{Log } U = \text{Log } U_0 + \sum_{n=1}^{N} u_n \text{Log } x_{n1}$
DISJUNCTIVE (DISJ)	$U = \prod_{n=1}^{N} U_0 \left(\frac{1}{a_n - x_{n1}}\right)^{u_n}$	$\text{Log } U = \text{Log } U_0 - \sum_{n=1}^{N} u_n \text{Log}(a_n - x_{n1})$
LOGARITHMIC (LOG)	$U = U_0 + \sum_{n=1}^{N} u_n \text{ Log } x_{n1}$	$U = U_0 + \sum_{n=1}^{N} r_n \text{ Log } x_{n1}$
EXPONENTIAL (EXP)	$U = \prod_{n=1}^{N} U_0 e^{u_n x_{n1}}$	$\text{Log } U = \text{Log } U_0 + \sum_{n=1}^{N} u_n x_{n1}$

TABLE 3

Mean, Standard Deviation, and Range of the Multiple Correlations for Each of the Five Models[a/]

RATING SET		STATISTIC	LINEAR	CONJ	DISJ	LOG	EXP
SAMPLE 1							
	Prior	Range	.62-.96	.63-.97	.49-.96	.62-.95	.64-.97
		$\bar{R}$	.87*	.87	.83	.85	.86
		σ	.083	.088	.093	.085	.078
	Post	Range	.54-.96	.52-.98	.50-.93	.45-.96	.59-.97
		$\bar{R}$	.85*	.84	.82	.84	.85
		σ	.099	.112	.088	.112	.169
	Revised	Range	.49-.95	.38-.98	.42-.94	.48-.96	.48-.96
		$\bar{R}$	.84*	.82	.78	.84	.83
		σ	.132	.156	.127	.139	.143
SAMPLE 2							
	Prior	Range	.65-.97	.63-.97	.69-.96	.58-.97	.68-.97
		$\bar{R}$	.90*	.90	.85	.89	.89
		σ	.071	.088	.086	.038	.069
	Post	Range	.45-.98	.36-.96	.36-.94	.43-.96	.39-.97
		$\bar{R}$	.87*	.87	.82	.87	.86
		σ	.104	.124	.108	.107	.118
	Revised	Range	.42-.96	.28-.97	.48-.96	.30-.96	.40-.97
		$\bar{R}$	.87*	.85	.84	.87	.85
		σ	.103	.137	.126	.125	.112

*Best Fitting Model (determined by carrying computations to four decimal places).

[a/]Significance Levels: for $p < .05$, $R = .81$; $p < .01$, $R = .88$.

TABLE 4

The Best Fitting Model for Each Judge in Each Rating Set--Sample 1

SUBJECT	PRIOR	POST	REVISED
1	LIN	EXP	LOG
2	LIN	LIN	LOG
3	DISJ	DISJ	LOG
4	CONJ	CONJ	LOG
5	LIN	LIN	DISJ
6	LIN	DISJ	LOG
7	CONJ	CONJ	LOG
8	CONJ	LIN	CONJ
9	DISJ	DISJ	DISJ
10	LOG	CONJ	LOG
11	LOG	LOG	LOG
12	LIN	CONJ	LIN
13	CONJ	CONJ	LIN
14	CONJ	CONJ	LIN
15	EXP	EXP	LIN
16	CONJ	CONJ	LOG
17	EXP	CONJ	EXP
18	LOG	LOG	EXP
19	CONJ	DISJ	CONJ
20	DISJ	DISJ	EXP
21	CONJ	CONJ	LOG
22	LIN	LIN	LIN
23	CONJ	CONJ	CONJ
24	LIN	LIN	CONJ
25	LIN	LIN	LIN
26	EXP	EXP	LOG
27	LIN	EXP	LIN
28	LIN	LIN	LOG
29	LIN	LIN	CONJ
30	CONJ	DISJ	LIN
31	DISJ	EXP	LOG
32	DISJ	EXP	LIN
33	LIN	LIN	LIN
34	DISJ	LIN	EXP
35	EXP	CONJ	EXP
36	EXP	CONJ	CONJ
AVERAGE	LIN	LIN	LIN

TABLE 4

(continued)

SUBJECT	PRIOR	POST	REVISED
Model <u>Frequency</u>			
LIN	12	10	11
CONJ	10	12	5
DISJ	6	6	2
LOG	3	2	13
EXP	5	6	5

TABLE 5

The Best Fitting Model for Each Judge in Each Rating Set--Sample 2

SUBJECT	PRIOR	POST	REVISED
1	LIN	EXP	CONJ
2	EXP	LOG	LIN
3	DISJ	DISJ	LIN
4	LOG	LOG	EXP
5	CONJ	LIN	LOG
6	LIN	LIN	LIN
7	LIN	LIN	CONJ
8	LIN	CONJ	DISJ
9	LIN	LIN	LIN
10	DISJ	CONJ	LIN
11	LOG	LOG	CONJ
12	LOG	CONJ	DISJ
13	LOG	LOG	LIN
14	LIN	LIN	LOG
15	LOG	CONJ	LOG
16	LIN	LIN	CONJ
17	LOG	LIN	DISJ
18	CONJ	LIN	LIN
19	LIN	LIN	CONJ
20	CONJ	CONJ	LOG
21	CONJ	EXP	DISJ
22	CONJ	CONJ	EXP
23	CONJ	EXP	DISJ
24	CONJ	LIN	LIN
25	DISJ	DISJ	LIN
26	CONJ	CONJ	LIN
27	CONJ	LIN	DISJ
28	EXP	LIN	DISJ
29	CONJ	CONJ	EXP
30	DISJ	LIN	CONJ
31	LIN	DISJ	DISJ
32	EXP	EXP	EXP
33	LIN	EXP	LOG
34	LOG	LOG	LIN
35	LIN	LIN	EXP
36	LIN	CONJ	CONJ
AVERAGE	LIN	LIN	LIN

TABLE 5

(continued)

SUBJECT	PRIOR	POST	REVISED
Model <u>Frequency</u>			
LIN	12	14	11
CONJ	10	9	7
DISJ	4	3	8
LOG	7	5	5
EXP	3	5	5

Research Hypotheses

II. Hypotheses Concerning Influence of the Group and Effects of Structure

A. Effects of Structure on Consensus Convergence

Research Hypothesis[a]	How Measured	Statistical Test[b]	Results
3. There will be greater agreement among members' post discussion ratings of the alternatives for all-channel groups than for wheel groups.	The Pearson product-moment correlation coefficient between group members' post-discussion ratings was computed and the values averaged across groups of the same type.	A t-test of differences in mean values of the Z-transformed r values. H_0: $\bar{r}_{08} - \bar{r}_{02} = 0$ vs. H_1: $r_{08} - r_{02} > 0$ d.f.: $n_1 = n_2 = 12$	$t = 1.27$ N.S.; fail to reject H_0. Hypothesis 1 is not supported but difference is in predicted direction.
4. Subgroup structure has no effect on subjects' prior decision models.	Compare the mean R's associated with different sets of ratings given by subjects.	A t-test was used to compare mean R's of subjects' post utility models for wheel and all-channel groups. H_0: $\bar{R}_W - \bar{R}_{ac} = 0$ vs. H_1: $\bar{R}_W - \bar{R}_{ac} \neq 0$ d.f.: $n_1 = n_2 = 12$	None of the differences for any of the models were significant except for the disjunctive model ($p < .10$). However, mean R's for all-channel groups were slightly larger than mean R's for wheel groups. Fail to reject H_0. Hypothesis is supported.
5. Same as 4	Same as 4	A t-test was used to compare mean R's of subjects' revised utility models for wheel and all-channel groups. H_0: $\bar{R}_W - \bar{R}_{ac} = 0$ vs. H_1: $\bar{R}_W - \bar{R}_{ac} \neq 0$ d.f.: $n_1 = n_2 = 12$	Fail to reject H_0, hypothesis is supported.

6. Members or both kinds of groups will tend to make their reassessments of the alternatives (post ratings) closer to the group assessments than to their original assessments (prior ratings).	Groups' recommendations were rated on 0-100 scale. Two indices were computed for each alternative: D_1 = prior rating-group rating; D_2 = post rating-group rating. These differences were summed across subjects and mean values computed.	Use t-test $H_0: \bar{D}_2 - \bar{D}_1 = 0$ vs. $H_1: D_2 - D_1 < 0$ d.f.: $n_2 = 68$, $n_1 = 68$ (w groups) $n_2 = 66$, $n_1 = 70$ (ac groups)	For ac groups: t = -2.48: reject H_0 at α = .01 level. For w groupsL t = -1.06 N.S., but in predicted direction. Hypothesis 8 is partially supported.

---

a/ Note: The names all-channel net and completely connected net are synonymous and are used interchangeably here.

b/ The degrees of freedom indicated may be less than the maximum possible, in some cases, given the total number of subjects and subgroups. This lower number of degrees of freedom is due to incomplete or unanswered items on the post-discussion questionnaires which were not discovered until after the experiments were completed.

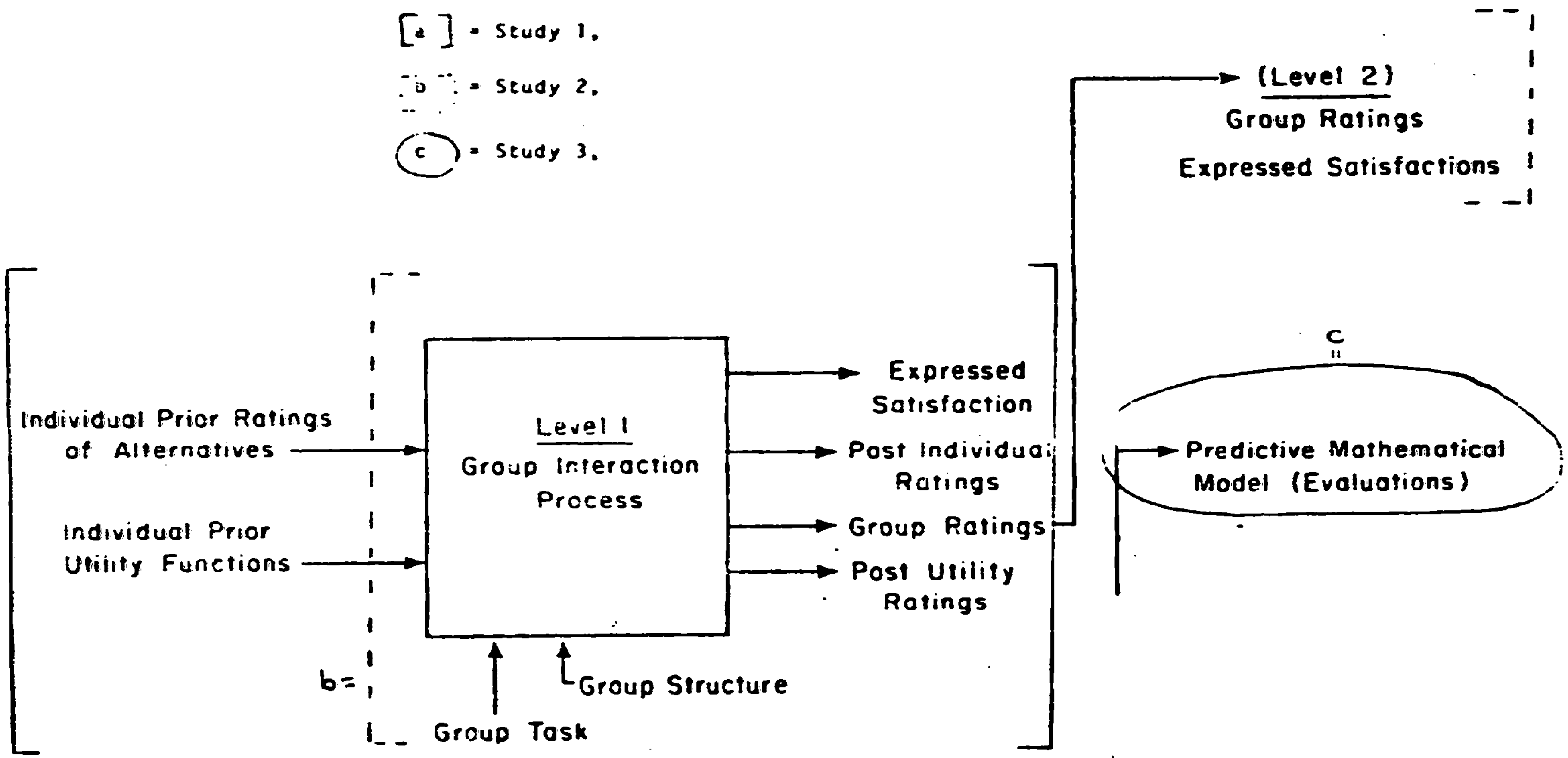


FIGURE 1

Model for Research Study

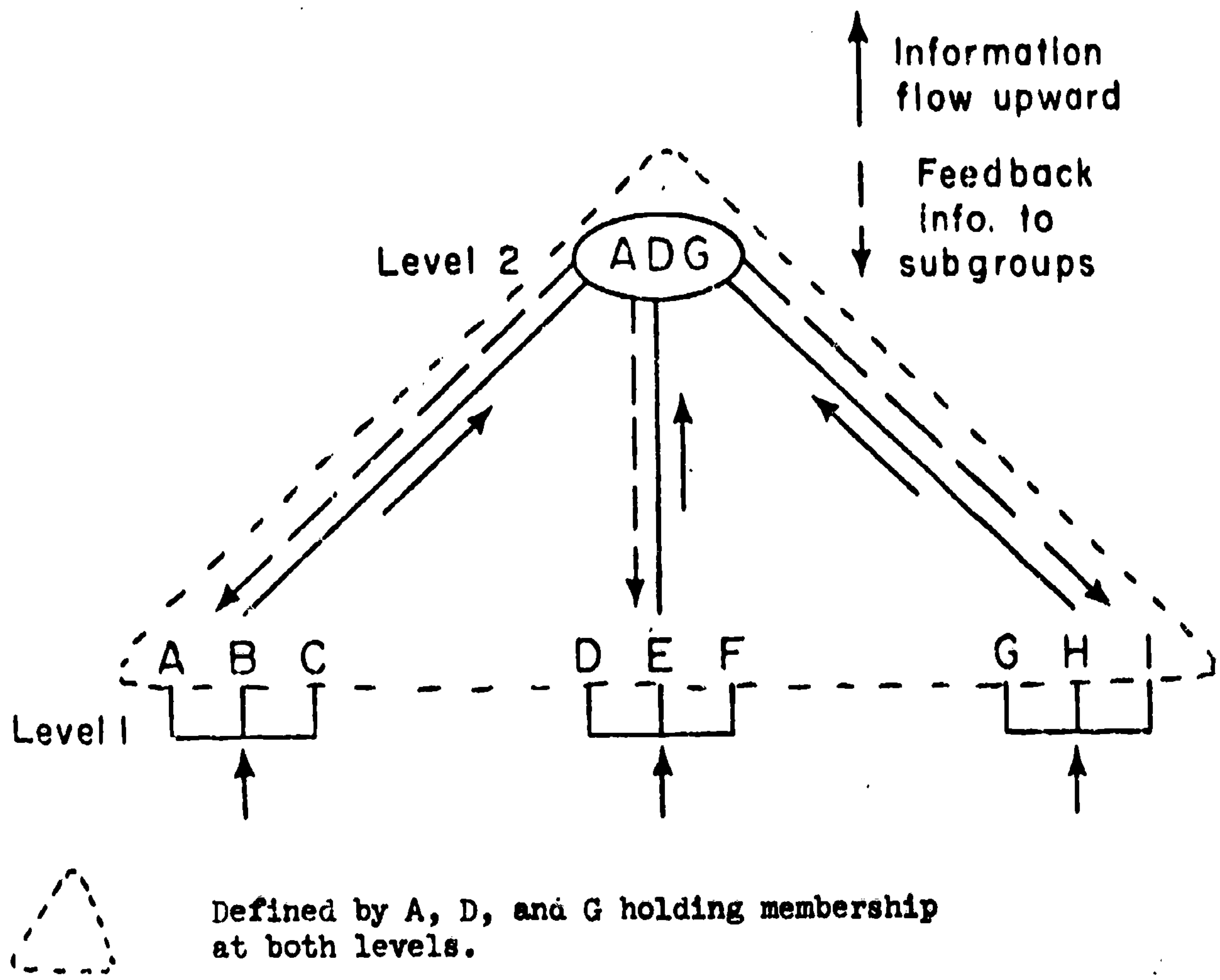


FIGURE 2

Organizational Structure

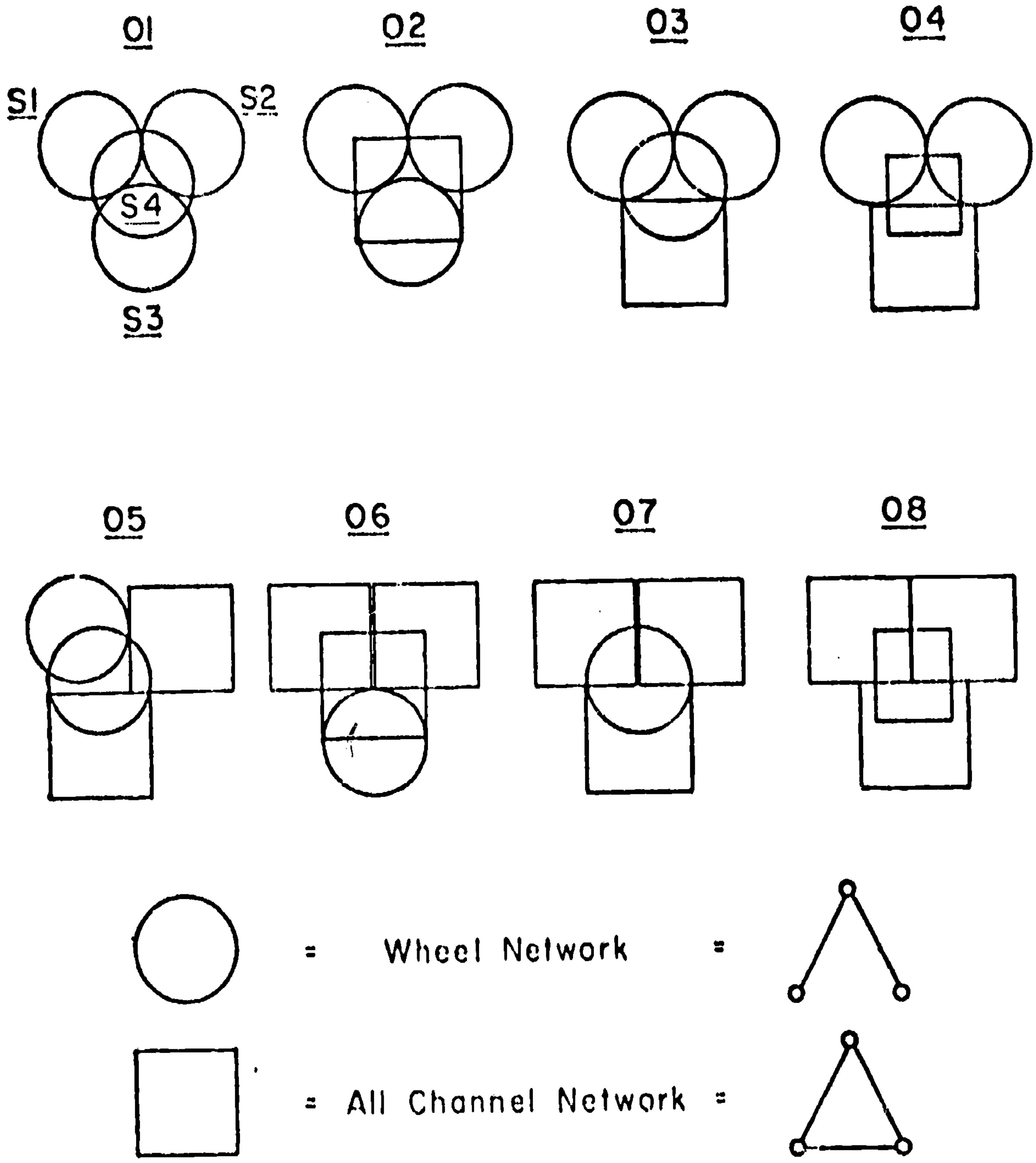
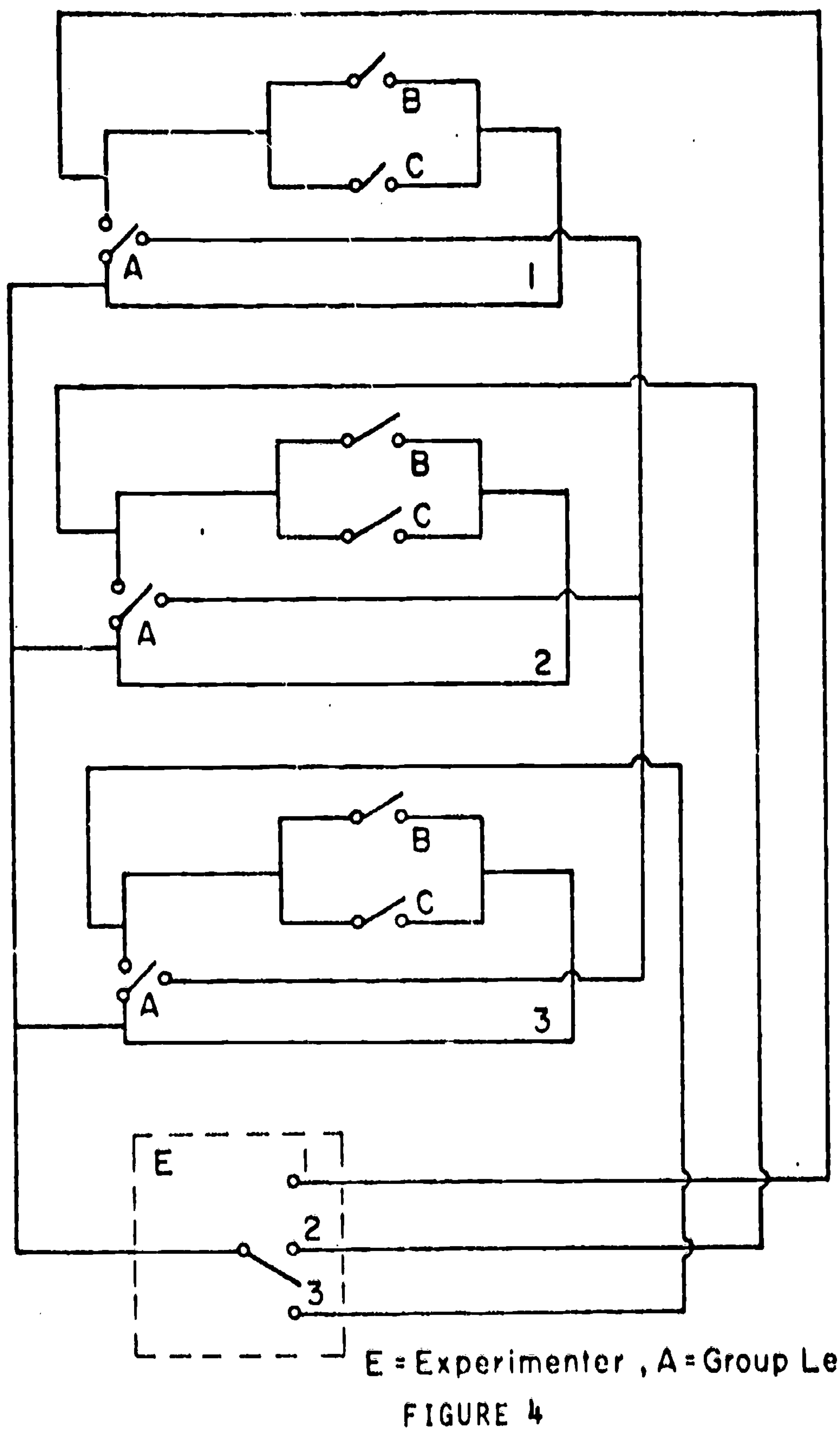


FIGURE 3

Possible Organizational Structures Showing
Four Subgroups



E = Experimenter , A = Group Leaders

FIGURE 4

Schematic Wiring Diagram of Communication Networks
Within Experimental Groups

Personal Appearance

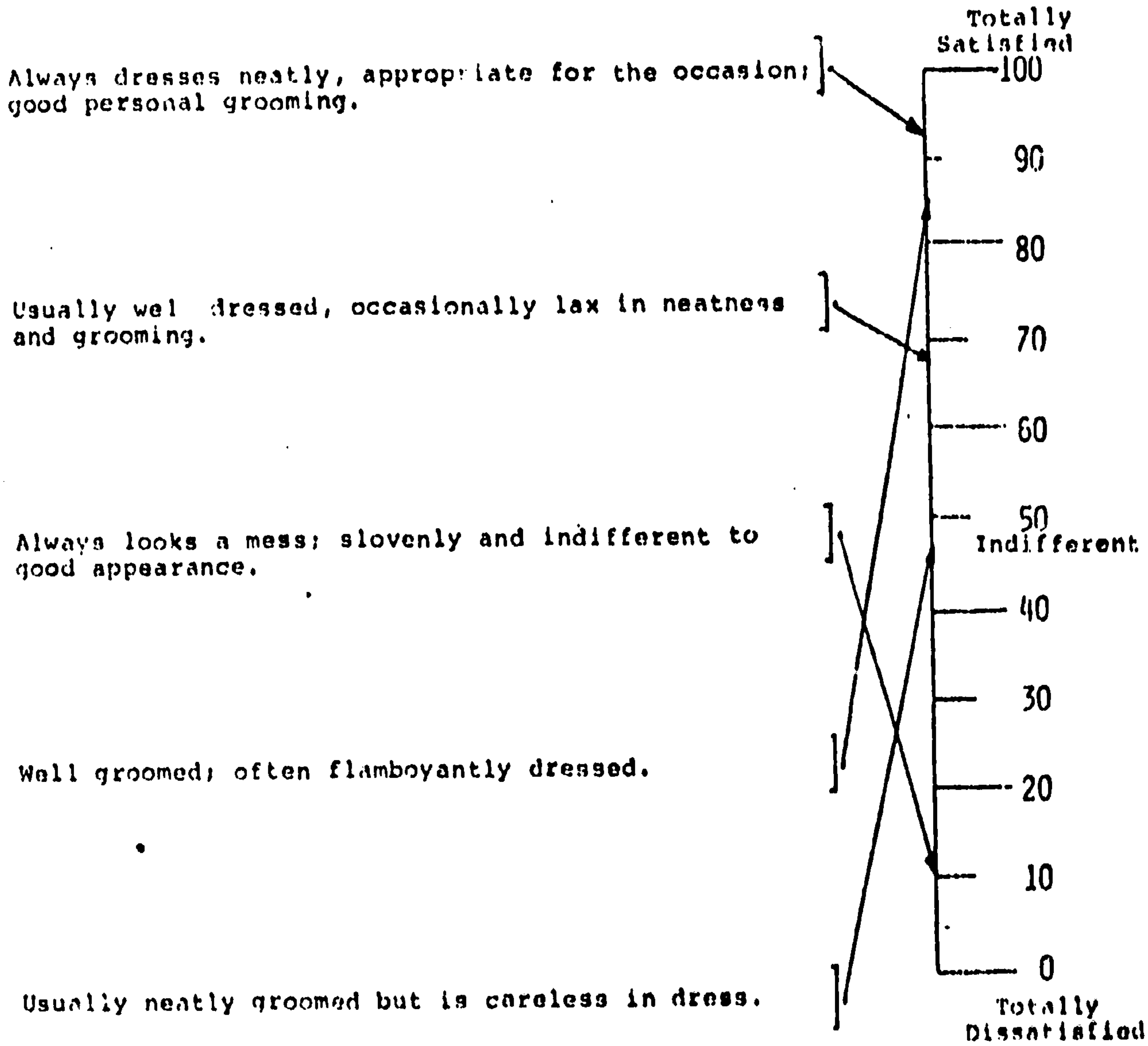


FIGURE 5

Example of a Completed Recording Instrument for the Factor "Personal Appearance"

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